Permitting Guidance for Oil and Gas Hydraulic Fracturing Activities Using Diesel Fuels – Draft: Underground Injection Control Program Guidance #84

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Executive Summary

This document contains draft guidance for permitting the underground injection of fluids as part of oil-and gas-related hydraulic fracturing (HF) using diesel fuels under the Safe Drinking Water Act (SDWA) Underground Injection Control (UIC) Program where the U.S. Environmental Protection Agency (EPA) is the permitting authority. EPA's goal is to explain existing requirements in order to provide regulatory certainty, improve compliance with the SDWA requirements and strengthen environmental protections consistent with existing law. Other environmental statutes and regulations may apply to other aspects of the HF process, such as surface handing of waste waters, chemicals, and air emissions, but are not addressed in this document. Additionally, permitting requirements, not covered in this document, may be applicable on federal lands. This draft guidance does not address State UIC programs, but EPA believes that the recommendations in this guidance may prove useful to State permit writers as well.

Recommendations in this draft guidance may change based on the comments received on the draft publication and this will be reflected in the final guidance. EPA understands that a permit writer who receives a permit application in the interim period before this guidance is finalized will have to make decisions about how to permit hydraulic fracturing wells using diesel fuels. While this guidance undergoes public notice and comment, EPA expects that decisions about permitting hydraulic fracturing operations that use diesel fuels will be made on a case-by-case basis, considering the facts and circumstances of the specific injection activity and applicable statutes, regulations and case law, and will not cite to this draft guidance as a basis for decision. Underground injection of fluids through wells is generally subject to the requirements of the SDWA. In the Energy Policy Act of 2005, Congress revised the SDWA definition of "underground injection" to specifically exclude from UIC regulation the "underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities" (SDWA Section 1421(d)(1)(B)). UIC regulations further provide that "[a]ny underground injection, except into a well authorized by rule or except as authorized by permit issued under the UIC program, is prohibited" (40 CFR 144.11). Thus, owners or operators who inject diesel fuels during HF related to oil, gas, or geothermal operations must obtain a UIC permit before injection begins.

This draft guidance includes EPA's interpretation that oil and gas hydraulic fracturing operations using diesel fuels as a fracturing fluid or as a component of a fracturing fluid are subject to UIC Class II requirements. The draft guidance recommends that UIC permit writers consider whether any portion of the injectate has one of six listed CASRNs, 68334-30-5, 68476-34-6, 68476-30-2, 68476-31-3, 8008-20-6, and 68410-00-4, or is referred to as "diesel fuel" in its primary name or common synonyms. Additionally, the guidance provides recommendations on how permit writers should implement UIC permitting requirements related to permit duration and well closure, permit application and review, area of review (AoR), and well construction, including mechanical integrity testing, financial responsibility, and public notification.

Purpose

EPA recognizes that natural gas plays a key role in our nation's clean energy future. We believe that this resource, if accessed in an environmentally responsible manner, has the potential to improve air quality, stabilize energy prices, and provide greater certainty about future energy reserves. The Agency is committed to ensuring that shale gas development occurs safely and responsibly, in a way that protects drinking water resources. This effort includes making sure HF as a method of natural gas drilling is conducted in an appropriate manner that protects public health and the environment while preserving the important economic and energy security benefits for America. To that end, this guidance is intended to clarify requirements under the SDWA and strengthen existing environmental safeguards to prevent the endangerment of underground sources of drinking water (USDWs).

This document describes UIC Program guidance for permitting the underground injection of oil- and gas-related HF using diesel fuels where EPA is the permitting authority. EPA's goal is to explain existing requirements in order to provide regulatory certainty, improve compliance with the SDWA requirements and strengthen environmental protections consistent with existing law. Other environmental statutes and regulations may apply to other aspects of the HF process, such as surface handing of waste waters, chemicals, and air emissions, but are not addressed in this document. Additionally, additional permitting requirements, not covered in this document, may be applicable on federal lands.

This guidance is designed to support EPA UIC permit writers in permitting injection for HF where diesel fuels are used. It describes existing legal requirements under the UIC Class II regulations. This includes recommendations for permitting HF where diesel fuels are used[1] under 40 Code of Federal Regulations (CFR) 144.52(a)(9), which provides the UIC Program discretion to tailor permit requirements as needed to ensure that USDWs are protected from endangerment.

EPA welcomes public input on this document during the public comment period. Please visit http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/hydraulic-fracturing.cfm, click on the "Outreach" tab, and follow the instructions to submit comments.

Recommendations in this draft guidance may change based on the comments we receive on the draft publication and this will be reflected in the final guidance. EPA understands that a permit writer who receives a permit application in the interim period before this guidance is finalized will have to make decisions about how to permit diesel fuels hydraulic fracturing wells. While this guidance undergoes public notice and comment, EPA expects that decisions about permitting hydraulic fracturing operations that use diesel fuels will be made on a case-by-case basis, considering the facts and circumstances of the specific injection activity and applicable statutes, regulations and case law, and will not cite to this draft guidance as a basis for decision.

[1] Also referred to as "HF using diesel fuels" or "diesel fuels HF" in this document.

Decisions made regarding a particular permit will be based on the applicable statutes, regulations, and case law, and at times may differ from the recommendations described in this guidance. Thus, this document will not impose legally binding requirements and will not be implemented as binding in practice; nor will it impose any obligations on private parties. Legally binding requirements for injection wells are found at 40 CFR Parts 124 and 144 through 148.

EPA UIC permit writers reviewing diesel fuels HF permit applications should refer to the provisions at 40 CFR Parts 124 and 144 through 147 as they make permitting decisions. This guidance does not substitute for UIC Class II regulations and is not itself a regulation. EPA focused on specific topics in this guidance, which are useful for tailoring Class II requirements to the unique attributes of hydraulic fracturing when diesel fuels are used.

Background

UIC Program Background

The SDWA mandates that EPA protect USDWs[2] from endangerment related to underground injection activities (SDWA Section 1421(b)(1)). The UIC Program requirements promulgated under SDWA authority and codified at 40 CFR Parts 124 and 144 through 148 create a regulatory framework to ensure protection of current and future USDWs from endangerment.

When EPA established the UIC Program, EPA identified six key "pathways of contamination," or ways in which fluids can escape through the injection well or other wells, or from the injection zone/interval, and enter USDWs. The identification of these pathways provided important information used to develop the minimum federal requirements for the permitting, siting, construction, operation, monitoring, and closure for five major classifications of injection wells, including wells associated with oil and gas activities (i.e., Class II wells). The pathways and the major technical UIC requirements developed to mitigate specific risks to USDWs are discussed in Appendix A of this document. The pathways are:

1. Migration of fluids through a faulty injection well casing;

2. Migration of fluids through the annulus located between the casing and well bore;

3. Migration of fluids from an injection zone through the confining strata;

4. Vertical migration of fluids through improperly abandoned and improperly completed wells;

5. Lateral migration of fluids from within an injection zone into a protected portion of that stratum; and

6. Direct injection of fluids into or above an underground source of drinking water.

UIC Program Implementation

Implementation of the UIC Program may be carried out by EPA regional offices, or by states, tribes, or territories, depending on whether a state[3] has received primary enforcement responsibility (primacy) approval from EPA to implement the UIC Program. Section 1421(b) of the SDWA mandates EPA to develop minimum federal requirements for states to ensure protection of USDWs. Where states do not apply for or receive primacy, EPA directly implements the UIC Program. EPA directly implements 14 state and territorial Class II UIC

[2] UIC Regulations at 40 CFR 144.3 define an Underground Source of Drinking Water (USDW) as "an aquifer or its portion: (a)(1) Which supplies any public water system; or (2) Which contains a sufficient quantity of ground water to supply a public water system; and (i) Currently supplies drinking water for human consumption; or (ii) Contains fewer than 10,000mg/l total dissolved solids; and (b) Which is not an exempted aquifer."
[3] Reference to "states" includes tribes and territories pursuant to 40 CFR 144.3.

programs as well as most tribal programs.[4] Information on states that have primacy is available at http://water.epa.gov/type/groundwater/uic/Primacy.cfm.

Because states regulate oil and gas production wells under authorities separate from SDWA authority, UIC Class II injection well regulations for HF using diesel fuels may be implemented through any of the following scenarios:

- EPA may be the UIC permitting authority for the Class II injection wells, while the state regulates oil and gas production wells under state oil and gas production authorities (e.g., Kentucky, Pennsylvania, New York, Tennessee);

- EPA may be the UIC permitting authority for the Class II injection wells and a tribe, or the Bureau of Land Management (BLM)—in fulfilling Federal government trust responsibilities to American Indian Tribes and individual Indian mineral owners—regulates oil and gas production wells (e.g., Uintah & Ouray Indian Reservation);

- A state or tribe may implement both an approved UIC Class II injection well program and the oil and gas production well program under state oil and gas production authorities; in such situations, both well types may be managed by the same department or agency (e.g., Alabama, Colorado, Fort Peck Assiniboine and Sioux Tribes, Ohio, Oklahoma, New Mexico, Texas, Utah, and Wyoming) or they may be managed separately by different state agencies, consistent with each agency's regulatory authority (e.g., Louisiana, Maryland, West Virginia).

Coordination between the state and EPA regulatory agencies commonly occurs both in states where EPA is the implementing authority for the UIC Program and in states where the state is the implementing authority for the UIC Program. Where EPA is the UIC permitting authority, EPA will permit diesel fuels HF in coordination with state oil and natural gas implementing agencies, as appropriate. Where EPA implements the program, EPA UIC permit writers should consider whether a Memorandum of Understanding (MOU) could be used to clarify implementation responsibilities (of EPA and the state) so that duplication of effort and transaction costs can be minimized. In addition, EPA UIC permit writers should consider whether informal or formal agreements such as cooperative permitting, inspection and surveillance, database sharing, and coordination of public notices could help avoid duplication.

Regulation of Hydraulic Fracturing in the UIC Program

For the purposes of this document, "hydraulic fracturing" (HF) is defined as a process used to stimulate producing formations (e.g., shale oil, gas shales, coal beds, tight sandstones, carbonate, and sandstone) and enhance recovery of oil or natural gas by pumping a mixture of fluids and other substances (e.g., water, chemicals, diesel fuels, and/or propping agents) into the target geologic formation under pressure, causing the formation to fracture.

[4] Exceptions are Fort Peck Assiniboine and Sioux Tribes and Navajo Nation.

Underground injection of fluids through wells is subject to the requirements of the SDWA except where specifically excluded by the statute. In the 2005 Energy Policy Act, Congress revised the SDWA definition of "underground injection" to specifically exclude from UIC regulation the "underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities" (SDWA Section 1421(d)(1)(B)).[5] UIC regulations further provide that "[a]ny underground injection, except into a well authorized by rule or except as authorized by permit issued under the UIC program, is prohibited" (40 CFR 144.11). Thus, owners or operators who inject diesel fuels during HF related to oil, gas, or geothermal operations must obtain a UIC permit before injection begins.

Permits for diesel fuels HF are available through the UIC Class II Program.[6] Owners or operators injecting diesel fuels during HF without a UIC Program permit may be subject to enforcement action under Section 1423 of the SDWA. In addition, owners or operators of HF wells are subject to the provisions of SDWA Section 1431 in the event of an imminent and substantial endangerment to the health of persons.

The classification scheme for UIC wells was created by and defined in EPA's regulations. There are now six categories of injection wells; five relate to specific activities and one (Class V) is a default for permitting activities that do not fall within another class. Since the inception of the UIC Program, Class II has been the primary well classification used for injection wells that are associated with oil and gas storage and production (40 CFR 144.6). Class II is also the well classification for injection wells used for enhanced recovery (ER) of oil or natural gas (40 CFR 144.6(b)(2)). As a form of enhanced recovery, HF fits most naturally within this category under EPA's regulations; this interpretation is also consistent with case law. In 2001, the Eleventh Circuit Court held that wells used for the injection of HF fluids fit within the definition of Class II wells under the UIC Program.[7]

On August 18 and November 18, 2011, the Secretary of Energy Advisory Board's (SEAB) Shale Gas Production Subcommittee recommended eliminating use of diesel as an additive to HF fluids (90-Day Report and Second 90-Day Report, respectively). States may at any time choose to eliminate HF using diesel fuels by prohibiting their use under state law.

Diesel Fuels

In accordance with UIC Program regulations (40 CFR 144.31(e)) it is the responsibility of the applicant to provide the information necessary for the permitting authority to make informed decisions, including characterization of the fluid to be injected (Class II wells, 40 CFR 146.23(b)(1) and 40 CFR 146.24(a)(4)(iii)). To understand, clarify and describe how diesel fuels can be identified for the purpose of this guidance EPA reviewed the SDWA, legislative history,

[5] This guidance does not address hydraulic fracturing using diesel fuels related to geothermal production activity.
[6] Class II is the well classification for oil and natural gas production fluids.
[7] The U.S. Court of Appeals for the 11th Circuit directed EPA to require Alabama to regulate hydraulic fracturing under SDWA. The court determined that EPA could regulate hydraulic fracturing under SDWA Section 1425, rather than Section 1422.

existing regulations, and industry and scientific literature. EPA reviewed the term "diesel fuels" as it is commonly used in industry standards and definitions, across various EPA programs and in various other federal programs. The Agency found that "diesel fuels" is not uniformly defined. Instead, diesel fuels are described or defined in a variety of ways including use-based definitions, chemical and physical property-based definitions, and refining process-based definitions.

Diesel fuels include a variety of complex substances refined from petroleum or crude oil that are known to contain varying amounts of constituents or impurities that result from the refining process or that are intentionally included to enhance desired properties, such as long-term storage and thermal stability. The properties of diesel fuel(s) depend on the refining practice. Additionally, the exact make up of diesel fuels may differ from one refinery to another (Speight, 2000).

Industry references to diesel fuels vary. For example:

- References such as Petroleum Refinery Processes (Speight, 2000) list diesel fuel as kerosine, kerosene, diesel oil, and middle distillates;

- Material safety data sheets (MSDS) from different refineries do not consistently identify diesel fuel as those constituents that include "diesel." The MSDS may be used to identify diesel fuels or a fluid containing diesel fuels, however. For example, diesel fuels identified from MSDSs include such names as Diesel Fuel Oil, Distillates, and "straight run."

- Chemical Abstract Service Registry Numbers (CASRNs) may also be used to identify diesel fuels. The CASRN system identifies chemical substances or molecular structures of a compound. Currently, several compounds identified in the system could be considered diesel fuels such as 68334-30-5, 68476-30-2, 68476-31-3, 68476-34-6, 8008-20-6, and 68410-00-4; or

- Some references include a description based on a fuel's suitability for use in a diesel engine.

EPA conducted a literature search[8] and had discussions with states, industry, and others to determine how diesel fuels are used or could be used in HF operations. Diesel fuels have been used for various components of HF fluid over the history of the practice (Rae and DiLullo, 1996) as a primary base (or carrier) fluid, or added to HF fluids as a component of a chemical additive.

In some cases, diesel fuels-based fracturing fluids are more efficient for transporting and delivering propping agents into fractures, as compared to water-based compounds. For example, formations that contain large amounts of clay can be subject to swelling and decreased permeability when exposed to water-based fluids (Cikes et al., 1988). Oil-based fluids such as

[8] Including American Society for Testing and Materials (ASTM) Standard Specification for Diesel Fuel Oils D975, National Institute for Standards and Technology; Encyclopedia of Petroleum Refinery Processes; Chemical Abstract Services; CRC Handbook of Chemistry and Physics; Refinery Material Safety Data Sheets.

diesel fuels are used to avoid clay swelling and allow for better production (Santerelli and Carminati, 1995). In addition, the lower freezing point of diesel fuels relative to water is advantageous for HF fluid handling in cold climate operations (Shibley and Leonard, 1987).

As an additive component, diesel fuels may be used for a range of purposes, including adjusting fluid properties (e.g., viscosity and lubricity) or as a solvent to aid in the delivery of gelling agents. For example, aluminum-based crosslinkers require the addition of diesel fuels or another oil-based solvent for optimal performance (Smith and Persinski, 1995). Diesel fuels are also used as a fluid loss additive. Diesel fuels' properties of high viscosity and immiscibility in water prevent fluid leak-off into a formation without impeding the production of hydrocarbons (Penny, 1982).

Some chemicals of concern occur in diesel fuels as impurities or additives, and include benzene, toluene, ethylbenzene, and xylene compounds (BTEX). BTEX compounds are highly mobile in ground water and are regulated under national primary drinking water regulations because of the risks they pose to human health. People who consume drinking water containing any of these compounds in excess of the maximum contaminant level (MCL; specified in the national primary drinking water regulations) over many years could experience:

- An increase in anemia or a decrease in blood platelets from benzene exposure;
- An increased risk of cancer from benzene exposure;
- Problems with the nervous system, kidneys, or liver from toluene exposure;
- Problems with the liver or kidneys from ethylbenzene exposure; and
- Damage to the nervous system from exposure to xylene.

Diesel fuels can also contain 20 to 60 percent polynuclear aromatic hydrocarbons (PAHs) by volume, which constitute some of the more toxic components of petroleum products. Diesel fuels can contain PAHs such as methylnaphthalene, methylphenanthrene, and other alkylated forms of organic priority pollutants that are listed under the Clean Water Act[9] and regulated as total PAHs under the national primary drinking water regulations.[10]

[9] 40 CFR Part 423—126 Priority Pollutants (Appendix A).
[10] Information on PAHs and regulations under the national primary drinking water regulations may be found at http://www.epa.gov/ogwdw/pdfs/factsheets/soc/tech/pahs.pdf.

Recommendations for Describing Diesel Fuels:
The draft guidance, directed toward EPA UIC permit writers, recommends considering whether any portion of the injectate has the following CASRNs. When assessing whether an HF activity is subject to UIC permitting requirements under the SDWA, EPA UIC permit writers should consider whether any portion of the injectate has any of the following CASRNs, or is referred to by its primary name or any of the associated common synonyms, some of which are provided as follows:

68334-30-5 Primary Name: Fuels, diesel
Common Synonyms: *Automotive diesel oil; Diesel fuel; Diesel oil (petroleum); Diesel oils; Diesel test fuel; Diesel fuels; Diesel Fuel No. 1; Diesel fuel [NA1993*[11]*]; Diesel fuel oil***;** EINECS[12] 269-822-7

68476-34-6 Primary Name: Fuels, diesel, no. 2
Common Synonyms: *Diesel Fuel No. 2; Diesel fuels no. 2***;** EINECS 270-676-1, *No. 2 Diesel Fuel*

68476-30-2 Primary Name: Fuel oil No. 2
Common Synonyms: *Diesel fuel*; *Gas oil or diesel fuel* or heating oil, light [UN1202] #2 Home heating oils; API No. 2 fuel oil; EINECS 270-671-4; Fuel Oil No. 2; Home heating oil No. 2; Number 2 burner fuel; Distillate fuel oils, light; Fuel No. 2; Fuel oil (No. 1,2,4,5 or 6) [NA1993];

68476-31-3 Primary Name: Fuel oil, no. 4
Common Synonyms: Caswell No.[13] 333AB; Cat cracker feed stock; EINECS 270-673-5; EPA Pesticide Chemical Code 063514; Fuel oil no. 4; *Diesel Fuel No. 4*

8008-20-6 Primary Name: Kerosene
Common Synonyms: JP-5 navy fuel/*marine diesel fuel*; Deodorized kerosene; JP5 Jet fuel; AF 100 (pesticide); Caswell No. 517; EINECS 232-366-4; EPA Pesticide Chemical Code 063501; Fuel oil No. 1; Fuels, kerosine; Shell 140; Shellsol 2046; Distillate fuel oils, light; Kerosene, straight run; Kerosine, (petroleum); Several others

68410-00-4 Primary Name: Distillates (petroleum), crude oil,
Common Synonyms: *Fuel, diesel (VDF)* (EPA SRS[14]), *Straight PWN diesel* (EPA SRS), Aruba gas oil; EINECS 270-072-8

Injectate containing substances with any of these six CASRN numbers would be subject to UIC permitting requirements. EPA selected these six CASRNs because either the primary name, or

[11] United Nations-North America (UN/NA) number.
[12] European Inventory of Existing Commercial Chemical Substances.
[13] A Caswell No. is an alphanumeric chemical identifier implemented by Robert L. Caswell in the 1960s and 1970s in conjunction with acceptable common names of pesticides names for labeling purposes.
[14] EPA Substance Registry System.

common synonyms, contain the term "diesel fuel" and they meet the chemical and physical description of "diesel fuel."

While EPA has recommended six existing CASRNs for UIC permitting purposes, EPA recognizes that new chemical compounds are developed and assigned new CASRNs on an ongoing basis and that some of these compounds may be substantially similar in chemical and physical structure to existing compounds in the list of six CASRNs. EPA may periodically update this list of CASRNs recommended for UIC permitting purposes, after providing notice and an opportunity for public comment.

When permitting HF in a well using diesel fuels as the carrier fluid or as a supplemental additive, EPA UIC permit writers should consider the entire mixture. EPA UIC permit writers should consider not only whether diesel fuel is injected on its own, but also whether it is injected as a component of other HF fluids. The Energy Policy Act, by specifically including the underground injection of diesel fuels pursuant to HF within the SDWA definition of "underground injection," signified Congress' intent to authorize regulation of the *practice* of underground injection of diesel fuels, as opposed to authorizing the setting of specific standards for diesel fuel injectates. This is consistent with the approach taken for all underground injection in the UIC Program, which is designed to ensure that underground injection practices—as opposed to the components of specific injectates—do not endanger drinking water sources.[15]

Class II regulations require that the owner or operator provide the complete chemical and physical characteristics of the injectate with the permit application. The chemical and physical characteristics may change for each subsequent HF event performed on the well, therefore monitoring of the injectate composition throughout the HF using diesel fuels is recommended (40 CFR 144.51(j) and 146.24(a)(4)(iii)). Information on injectate composition will be important to the EPA UIC permit writer in considering permit conditions for the specific injection activity to prevent endangerment to USDWs. The following are some factors that should be examined when considering permit conditions:

- Compatibility of the injection fluid with formation fluids;
- Subsequent geochemical reactions resulting from injection;
- The effect of the injection on integrity of construction materials; and
- Mobility of compounds in the injection zone.

EPA UIC permit writers should not consider the use of biodiesel in HF activities as diesel fuel under the SDWA unless biodiesel is blended with petroleum-derived diesel fuels. The vast majority of plant-derived diesel fuels, or biodiesel, typically contain significantly lower levels of chemicals of concern compared to petroleum-derived diesel fuels. However, when biodiesel

[15] Put forth in the preamble of the SDWA UIC Regulations.

fuels are combined or blended with petroleum-derived diesel fuels, EPA recommends that the blended product be considered diesel fuels for purposes of permitting diesel fuels HF activities.

EPA expects that diesel fuels that are used at a project site for ancillary, non-injection purposes, such as running a diesel engine or use in a pipe joint compound, should not be subject to UIC permitting since they are not injected.

Guidance for Wells that Use Fluids Containing Diesel Fuels for Hydraulic Fracturing

The remainder of this document describes current requirements and recommendations for permitting diesel fuels HF wells where EPA directly implements the UIC Program. Each subsection provides a brief summary of the existing federal UIC Class II regulations followed by recommendations for tailoring UIC Class II requirements to diesel fuels HF, as envisioned under the regulations. Owners or operators may find the recommendations provided in this guidance helpful when planning to construct or operate a diesel fuels HF well. State UIC Program Directors have the discretion to adopt the recommendations provided in this and other EPA UIC Program guidance documents. Primacy programs can include different or additional conditions in permits, as well.

The following questions are addressed in this guidance:

- Can Multiple UIC Class II Wells Using Diesel Fuels for HF Be Authorized by One Permit?
- How Should EPA UIC Permit Writers Establish a Permit Duration and Apply UIC Well Closure Requirements After Fracturing at a Well Ceases?
- What Are Considerations for the Diesel Fuels HF Permit Application Submission and Review Process?
- How Do the Area of Review (AoR) Requirements at 40 CFR 146.6 Apply to Wells Using Diesel Fuels for HF?
- What Information Should Be Submitted with the Permit Application?
- How Do the Class II Well Construction Requirements Apply to HF Wells Using Diesel Fuels?
- How Do the Class II Well Construction Requirements Apply to Already Constructed Wells Using Diesel Fuels HF?
- How Do the Class II Well Operation, Mechanical Integrity, Monitoring, and Reporting Requirements Apply to HF Wells Using Diesel Fuels?
- How Do the Class II Financial Responsibility Requirements Apply to Wells Using Diesel Fuels for HF?
- What Public Notification Requirements or Special Environmental Justice (EJ) Considerations are Recommended for Authorization of Wells Using Diesel Fuels for HF?
- Does this Guidance Apply to States, Tribes, and Territories with Primacy?

Can Multiple UIC Class II Wells Using Diesel Fuels for HF Be Authorized by One Permit?

Existing Requirements: An area permit is an option for authorizing injection where there are multiple wells drilled by one owner or operator within a well-defined, localized area and production interval. As provided in 40 CFR 144.33(a), an area permit may be authorized in lieu of an individual permit for each well if the following conditions are met:

- If the permit is for existing wells, the permit application must describe and identify each well by location (unless the existing wells have substantially the same characteristics, in which case, a single description may be sufficient). (Note that this description and identification requirement does not apply if the permit is for new wells.)

- The wells are operated by a single owner or operator.

- The wells are within the same well field, facility site, reservoir, project, or similar unit in the same state.

- The wells are not used to inject hazardous waste.

The regulations at 40 CFR 144.33(b) also specify what must be included in an area permit. Area permits must specify the area within which underground injection is authorized and the requirements for construction, monitoring, reporting, operation, and plugging and abandonment for all wells authorized by the permit. As provided in 40 CFR 144.33(c), the area permit may authorize the permittee to construct and operate, convert, or plug and abandon additional wells within the permit area provided:

1. The permittee notifies the UIC Program Director at such time as the permit requires;

2. An additional well satisfies the criteria for inclusion in the area permit (as specified in 40 CFR 144.33(a)) and meets the requirements specified in the permit (under 40 CFR 144.33(b)); and

3. The cumulative effects of drilling and operation of additional injection wells are taken into account by the UIC Program Director during evaluation of the area permit application and are acceptable to the UIC Program Director.

Recommendations: ***EPA UIC permit writers should consider issuing area permits for Class II wells using diesel fuels for HF, provided that all applicable requirements, including any applicable public notification requirements, are satisfied.*** Issuing area permits may result in improved permitting efficiency, especially in areas with large numbers of Class II wells using diesel fuels for HF. EPA UIC permit writers should also take into account the total number of proposed wells that will be covered by the area permit when determining the appropriate financial responsibility demonstration to ensure that sufficient resources are available to protect USDWs.

How Should EPA UIC Permit Writers Establish a Permit Duration and Apply UIC Well Closure Requirements After Fracturing at a Well Ceases?

Existing Requirements: Under the UIC Program, a well may be:

- Permitted as an active injection well for the life of the facility and subject to all applicable Class II requirements;
- Converted out of the UIC Program after injection ceases (meaning the permit duration ends upon conclusion of HF and post-HF monitoring); or
- Managed as a temporarily abandoned (TA) injection well during times when injection ceases or is curtailed.

UIC regulations at 40 CFR 144.36(a) allow for a Class II permit to be issued up to the operating life of the facility. UIC regulations at 40 CFR 144.36(c) allow a permit to be issued for a duration less than the full allowable term (i.e., the operating life of the facility) indicated at 40 CFR 144.36(a). UIC regulations at 40 CFR 144.52(a)(6)(ii) also allow for the temporary or intermittent cessation of injection[16] during the duration of the permit, provided that the owner or operator describes, and the EPA Regional Administrator (RA) approves, actions and procedures that the owner or operator will take to ensure that the well will not endanger USDWs during the period of temporary abandonment.

Finally, UIC regulations at 40 CFR 144.51(n) and 144.52(a)(7)(i)(B) allow for conversion of an injection well out of the UIC Program, in situations where injection has ceased and production operations are occurring. If a well is converted out of the UIC Program it is no longer subject to UIC requirements after the permit expires, but may not conduct future underground injection activities (i.e., injection of diesel fuels for HF) unless a new permit is obtained.

An owner or operator may request the UIC Program Director to consider alternative requirements for operation, monitoring, and reporting than required in 40 CFR 146 or 144.52 to the extent that reductions in requirements will not result in an increased risk of movement of

[16] The EPA permit writer has the option of ending the permit duration after the conclusion of injection or managing the well as temporarily abandoned. Further, regulations state that "temporary or intermittent cessation of injection operations is not abandonment," for the purposes of well closure plans (40 CFR 144.51(o)). Therefore, temporarily abandoned wells remain subject to well closure requirements.

fluid into a USDW (40 CFR 144.16). A well may be considered as meeting the conditions of 40 CFR 144.16 if:

- It is not injecting (e.g., while the well is producing and no injection is occurring); and
- It has a radius of endangering influence[17] that is smaller than the radius of the well (i.e., components, including casing, tubing, etc.) when computed using the formula at 40 CFR 146.6(a). This could occur when the well is producing (e.g., when no injection is occurring) and the injection rate is zero.

Recommendations: EPA recommends the EPA UIC permit writer consider one of two ways of setting a permit duration for the individual diesel fuels HF well: (1) set a short duration or (2) temporarily abandon the well.

(1) Set a short duration for the permit, as permissible under 40 CFR 144.36(c), and allow conversion out of the UIC Program after injection ceases and a non-endangerment demonstration is made. Compliance with UIC permit conditions should be confirmed before the injection permit duration ends, and prior to releasing it from UIC requirements. Where an owner or operator of a production well wishes to refracture using diesel fuels after the conclusion of the UIC permit, the owner or operator will need to receive a new, approved UIC permit before refracturing can occur. EPA recommends that the duration of a permit that is less than the full allowable term still allow adequate time to collect monitoring data, which demonstrates that injection during the HF operation has not endangered USDWs in the project area. This time-frame is likely to vary, depending on site-specific factors.

(2) Manage the well as temporarily abandoned during periods of oil or gas production (e.g., when no injection is occurring). This option may be preferable in situations where the well owner or operator plans to refracture at some point in the future. When managing a well as temporarily abandoned, the EPA UIC permit writer should use his or her authorized discretion under 40 CFR 144.52(a)(9), to tailor permit conditions on a case-by-case basis. Permit requirements that could be reduced while a well is producing hydrocarbons, include frequency of mechanical integrity testing; ground water quality, injection pressure, flow rate and cumulative volume monitoring; and select reporting requirements. However, permit conditions should still ensure that well integrity is maintained and injected fluids do not migrate out of the injection zone during production. This option requires that the UIC permit remain active until final plugging and abandonment of the well.

Regardless of the permit duration approach, the EPA UIC permit writer should ensure that a well closure (plugging and abandonment) plan is incorporated into the permit, which meets both the goals of the production program and the UIC goals of protecting USDWs from endangerment. Although in option (1) the UIC well closure plan might not be enacted during the period of the permit, ensuring that an appropriate plan has been formulated for use under the production well

[17] The zone of endangering influence (ZEI) is the lateral area in which the pressures in the injection zone may cause injection or formation fluid to migrate into a USDW (further described in Appendix B).

permit provides some assurance that appropriate plugging and abandonment measures will be taken at the end of the facility's life.

For area permits, the EPA UIC permit writer should set the duration of the permit so that the area permit does not expire until after the closure of all wells covered by the permit or after the conversion of all wells to oil and gas production (out of the UIC Program)(40 CFR 144.51(n)). For such UIC area permits, the EPA UIC Program Director should review the permit conditions after the first few wells are drilled and hydraulically fractured to make adjustments, as needed, based upon any new data collected. Thereafter, permit conditions should be reviewed at least once every five years for the duration of the area permit. In addition, the EPA UIC permit writer should ensure that wells are in compliance with all aspects of the UIC area permit prior to releasing any from UIC Program requirements.

Properly closing an injection well is critical to assuring the long-term prevention of contamination of USDWs by eliminating a potential pathway, or pathways, for contamination. Both the UIC Program and state oil and gas programs require well closure. Coordination should be feasible because state oil and gas programs typically require closure, plugging, and abandonment activities for production wells that are similar to what the UIC Program requires for underground injection wells.

As stated previously, where an owner or operator of a production well wishes to refracture a well that had been released from the UIC Program by being fully converted to production, the owner or operator would need to submit a new UIC permit application.

What Are Considerations for the Diesel Fuels HF Permit Application Submission and Review Process?

Existing Requirements: For the purposes of UIC Class II permitting, any well being permitted is considered a "new injection well" (40 CFR 144.31), even if it was already constructed as an oil and gas well, and must comply with all UIC Class II requirements. All injection activities including injection well construction, or retrofitting, are prohibited until the owner or operator is authorized by a permit. Permits are required prior to commencing injection of diesel fuels during HF. An owner or operator seeking a UIC permit for injection must submit an application for a permit as expeditiously as practicable and in a reasonable amount of time prior to the expected start of construction, as determined by the EPA UIC permit writer (40 CFR 144.31).

Recommendations: ***EPA UIC permit writers should establish a UIC permit application submission timeframe, consistent with 40 CFR 144.31, to assist owners or operators in planning for wells in which diesel fuels HF activities will occur.*** The application timeframe should allow a reasonable amount of time prior to the HF event to evaluate the proposed diesel fuels HF activity and ensure that it will not endanger USDWs and to process and issue a UIC permit. The permit review time frame should be of a sufficient duration to allow the EPA UIC permit writer to comprehensively consider all relevant permit information, such as proposed construction, operation, and monitoring plans, establish appropriate permit conditions, and to include an opportunity for public notice and comment prior to issuing approval of the UIC Class II permit for wells using diesel fuels for HF.

EPA recommends that EPA UIC Program Directors continue to coordinate with the state oil and gas program or the appropriate BLM office, to establish a mechanism to inform owners or operators of applicable UIC Program requirements and application deadlines. Multiple mechanisms for outreach should be used to notify owners or operators of expected permit application review and approval timeframes thereby preventing delays for drilling and construction. EPA UIC permit writers should, at a minimum, use a publicly accessible website and mail a notice to current well owners or operators notifying them of the applicable UIC permit deadline.

Collaboration among regulatory entities is important so that appropriate parties are aware of situations where owners or operators plan to use diesel fuels during HF, and all parties can work together to comply with the UIC Program requirements and increase consistency between various permitting requirements. EPA's recommendation to coordinate with appropriate state and federal programs is consistent with the SEAB August 18 and November 18, 2011 recommendations to improve communication among federal and state regulators. The EPA UIC permit writer may consider working with the oil and gas program to add a check box, notation, or UIC Program contact information on the oil and gas drilling permit application forms that can be used to alert owners or operators using diesel fuels for HF of the need to apply for a Class II UIC permit.

How Do the Area of Review (AoR) Requirements at 40 CFR 146.6 Apply to Wells Using Diesel Fuels for HF?

Existing Requirements: The AoR is defined at 40 CFR 146.3 as "the area surrounding an injection well described according to the criteria set forth in §146.6 or in the case of an area permit, the project area plus a circumscribing area the width of which is either ¼ of a mile or a number calculated according to the criteria set forth in §146.6." At 40 CFR 146.6, the AoR must be determined by one of two methods: (1) determining the zone of endangering influence (ZEI), or (2) using a minimum one-quarter (¼) mile fixed radius around the well. The EPA UIC permit writer may solicit input as to which method is most appropriate for each geographic area or field. If the AoR is determined by modeling, the permissible radius is the result of the modeling, even if it is less than one-quarter (¼) mile.

Delineating and evaluating an AoR is one of the cornerstones of the UIC Program. It ensures that there are no conduits in the vicinity of the injection well that could enable fluids to migrate into USDWs. Before proceeding with the project, the owner or operator must define the appropriate AoR; assess that area for conduits of potential fluid movement; and, if necessary, perform corrective action, such as the plugging of improperly abandoned and orphaned wells, or re-siting of the planned well to account for any conduits that could potentially cause migration of contaminants into USDWs. These AoR requirements and EPA's AoR recommendations below enhance the protection of groundwater quality and support the management of short-term and cumulative impacts on communities, land use, wildlife, and ecologies as recommended by the SEAB on August 18 and November 18, 2011.

Recommendations: ***EPA UIC permit writers should modify the one-quarter (¼) mile fixed radius approach to delineating the AoR so that it is sufficiently protective of USDWs.*** Site-

specific AoR determinations are needed to address the full extent, shape, and size of the AoR for diesel fuels HF projects due to variations in geology, operations, and directional drilling, which typically extends beyond one-quarter mile from the wellhead. Modifying the fixed radius approach may require the EPA UIC permit writer to review past HF activities in each geographic area or field, and consult with the owner or operator about the design and anticipated results for the fracturing operation. Information needed in evaluating the appropriate AoR delineation method includes three-dimensional well orientation and anticipated fracture length. In addition, multiple wells co-located on the same well pad introduce complexities into the AoR delineation and assessment process. Thus, owners or operators using multi-well pads should include length and angle of each directional completion, fracture length, and an estimation of how closely the fractured zone approximates a porous medium. Approaches to applying the one-quarter (¼) mile fixed radius are discussed further in **Appendix B**.

EPA recommends against using the modified Theis equation found at 40 CFR 146.6 to determine the zone of endangering influence for directional wells, because directional wells do not meet the equation's assumptions for the well, the aquifer conditions, and the similarity of hydraulic properties between the injectate and the in situ groundwater. Further discussions of the Theis equation's limitations are found in **Appendix B**: Methods for Calculating the Area of Review.

What Information Should Be Submitted with the Permit Application?

Existing Requirements: The regulations at 40 CFR 144.31, 144.51, 146.22, and 146.24 describe the information needed by the UIC Program Director to authorize Class II wells. Such information includes (but is not limited to):

- Maps showing the injection well or project area for which the permit is sought and the applicable AoR showing the number or name and location of all producing wells, injection wells, abandoned wells, and other features (40 CFR 146.24(a)(2));

- All known wells within the AoR or ZEI that penetrate formations affected by the increase in pressure (40 CFR 146.24(a)(3));

- Data on the injection and confining zones including lithologic description, geological name, thickness and depth, and estimated fracture pressures of the injection and confining zones (40 CFR 146.24(a)(5));

- The location, orientation, and properties of known or suspected faults and fractures that may transect the confining zone(s) in the AoR and a determination that they would not interfere with containment (40 CFR 146.24(a)(2));

- Geologic name and depth to the bottom of all USDWs which may be affected by the injection (40 CFR 146.24(a)(6));

- Well construction schematics including surface and subsurface details (40 CFR 146.24(a)(7));

- Proposed stimulation [fracturing] program (40 CFR 146.24(b)(2)) and the proposed injection procedure [for each stage of the HF] (40 CFR 146.24(b)(3));

- Operating data such as average and maximum daily rate, volume, and injection pressure of fluids to be injected, and the source, as well as appropriate analysis of the chemical and physical characteristics of the injection fluid to establish permit conditions protective of USDWs (40 CFR 146.24(a)(4));

- Names and addresses of all owners of record of land within one-quarter (¼) mile of the well boundary (40 CFR 144.31(e)(9));

- Appropriate logs and other tests conducted during the drilling and construction of wells and reports interpreting the results of the tests as described in 40 CFR 146.24(c)(1); and

- If applicable to the duration of the permit, a plugging and abandonment plan that meets the requirements of 40 CFR 146.10, which describes the need to cement a well to prevent fluid movement (40 CFR 144.31(e)(10)).

Information submitted and evaluated during the permit application process supports permitting decisions and ensures that appropriate safeguards (e.g., permit conditions) are established to prevent or remedy contamination to USDWs.

Recommendations: ***EPA UIC permit writers should request, per their authorized discretion under 40 CFR 144.52(a)(9), and review additional information from the owner or operator when evaluating a permit application for a diesel fuels HF well.*** The UIC regulations allow flexibility in permitting to account for local conditions and practices. Because of the high injection pressures, the potential to induce fractures that may serve as conduits for fluid migration, and concerns about inducing seismic events involved with HF—along with the particular risks associated with diesel fuels—EPA UIC permit writers may need the following types of information to make sound permitting decisions:

- Maps and cross sections of the AoR showing the extent and orientation of the planned fracture network, any nearby USDWs, and their connections to surface waters, if any,[18] as well as any other information that can be used to understand, calculate and delineate the extent and orientation of the fracture system expected to be created by the proposed diesel fuels HF activity, such as results from previous HF operations in the area and other empirical information, models, and published studies and reports;

- A plugging and abandonment plan or pre-permit-expiration plan that incorporates monitoring of USDWs in the AoR to demonstrate non-endangerment. Monitoring parameters could include groundwater flow and depth; total dissolved solids (TDS); specific conductance; pH; chlorides; bromides; acidity; alkalinity; sulfate; iron; calcium;

[18] Such information may be best represented on maps, cross sections or other graphical representations submitted with the permit application (40 CFR 146.24).

sodium; magnesium; potassium; bicarbonate; detergents; diesel range organics (DRO); and BTEX;

- A detailed chemical plan describing the proposed fracturing fluid composition, including the volume and range of concentrations for each constituent (as per 40 CFR 146.24(a)(4)(iii)); and

- Baseline geochemical information on USDWs and other subsurface formations of interest within the AoR of a Class II diesel fuels HF well (as per 40 CFR 146.22(b)(2)(i) and (f)(2), which require the characterization of formation fluids through logging and testing that may be needed given site conditions). This geochemical information could include parameters, such as TDS; specific conductance; pH; chlorides; bromides; acidity; alkalinity; sulfate; iron; calcium; sodium; magnesium; potassium; bicarbonate; detergents; DRO; and BTEX.

The above recommendations are similar to those practices recommended by American Petroleum Institute (API) guidance (API, 2009). Information that owners or operators could also provide with a production permit application includes the anticipated true vertical depth(s) of the formation(s) to be hydraulically fractured and the anticipated pressure range for the proposed HF treatment(s). This is similar to language used in the Draft Model Regulatory Framework proposed by Southwestern Energy (SWN) and Environmental Defense Fund (EDF) (SWN-EDF, 2010). This information can provide EPA UIC permit writers with important data to assess whether HF operations using diesel fuels would endanger USDWs. These recommendations are consistent with the approaches taken by several state oil and gas programs that have promulgated new rules that require additional information be submitted or provided related to HF operations. In addition, these recommendations and above information requirements ensure the protection of water quality and help develop best practices to improve short-term and cumulative environmental outcomes as advocated by the SEAB.

How Do the Class II Well Construction Requirements Apply to HF Wells Using Diesel Fuels?

Existing Requirements: Construction requirements are found at 40 CFR 144.52 and 146.22. Design standards for Class II injection wells, including Class II HF wells using diesel fuels, are intended to prevent movement of fluids that could endanger USDWs. These requirements and EPA's construction recommendations promote the adoption of best practices in well development and construction, as recommended by the SEAB on August 18 and November 18, 2011, to avoid methane migration and leakage during production. EPA UIC permit writers may consider a number of factors when determining the proper well components such as casing and cementing for new Class II HF wells using diesel fuels. Different considerations may apply for already constructed wells.[19] (See "How Do the Class II Well Construction Requirements Apply

[19] For this guidance document, an "already constructed well" generally refers to an oil and gas production well that was constructed prior to issuance of this guidance and may meet the definition of either an "existing well" or a new injection well as defined in 40 CFR 144.3.

to Already Constructed Wells Using Diesel Fuels HF?" for applicable information on already constructed wells.)

Class II wells must be cased and cemented to prevent movement of fluids into or between USDWs (40 CFR 146.22). EPA UIC permit writers must consider the following factors in determining casing and cementing requirements:

- Geology of the injection and confining zones including the estimated formation fracture pressure;
- Depth from surface to the injection zone and to the bottom of each USDW down to and including the lowermost USDW; and
- Proposed operating procedures including maximum and average injection pressures (40 CFR 146.22(b)(1) (iii)).

To ensure that the well has been completed, cement has been emplaced properly, and zonal isolation has been obtained, appropriate logs and other test results such as sonic, cement bond, and fracture finder logs, must be maintained during the drilling and construction of Class II HF wells using diesel fuels (40 CFR 146.22).

Recommendations: ***EPA UIC permit writers should ensure that surface casing and cement extend through the base of the lowermost USDW and should review additional information when specifying casing and cementing requirements for Class II HF wells using diesel fuels (consistent with 40 CFR 144.52(a)(9)).*** Extending the surface casing and cement below the base of the lowermost USDW isolates USDWs during well completion and injection, ensuring that overlying USDWs are not exposed to drilling fluids, additives, formation fluids or gases, all of which could migrate into unprotected USDWs. In addition, extending the surface casing and cement below the base of the lowermost USDW provides additional protection to overlying USDWs in the event of well failure. This is consistent with federal requirements for several classes of injection wells, is recommended in API guidance (API, 2009),[20] and is a requirement for production wells in several states.

EPA UIC permit writers should ensure that owners or operators take extra precautions in the construction of wells for diesel fuels HF due to the high injection pressures needed for HF. Additional information that could assist the EPA UIC permit writer in specifying casing and cementing requirements include:

- A description of the geologic formations overlying the production zone, and whether they might contain gas, oil, or other potentially mobile contaminants that should be isolated from the well by cement. Isolating zones of potential contaminants would decrease the risk of endangerment to USDWs from movement of contaminants into nearby USDWs;

[20] *API Guidance Document HF1* recommends that surface casing, at a minimum, be set at least 100 feet below the deepest USDW encountered.

- The physical and chemical characteristics of the formation fluids in the injection zone and the proposed characteristics of the well such as the size of the bore hole, which are needed to determine appropriate construction materials for the use and life of the well. Construction materials should maintain integrity over the life of the well in order to protect USDWs. Formation fluids may be corrosive to casing and tubing. In addition, the EPA UIC permit writer should determine if the injection zone is a USDW and if so initiate appropriate steps to determine whether an exemption could be considered or whether the permit should be denied;

- Location and operating procedures of other active injection wells or wells undergoing HF in the AoR or nearby injection zones. Pressures external to the well coupled with injection pressure may cumulatively affect the integrity of the construction materials and fracture pressure of the injection zone. Exceeding the capability of the construction materials would cause failure of mechanical integrity and possible leaks of fluids into USDWs. Exceeding the fracture pressure of the injection zone risks fracturing confining zones and creating conduits for fluids to move into USDWs;

- Data on sizes and grades of the casing string and classes of cement to be used in construction (40 CFR 146.22(b)-146.22(g));[21]

- The proposed cementing plan to ensure proper cement design and volume. Related information of particular importance includes the capability of the typically lower-density "lead" cement to adequately isolate overlying USDWs, which would assist in evaluating if the higher-density and compressive-strength "tail" cement coverage should be modified (placed higher) to effectively isolate and afford appropriate protection of overlying USDWs; and

- Additional information to ensure that long, multi-well pad horizontal wells will be constructed in a protective manner.

These additional considerations can help to ensure that the well is designed and constructed for the unique geologic environment and planned diesel fuels HF operations.

The EPA UIC permit writer may also consider additional testing requirements to demonstrate that the well maintains mechanical integrity before, during, and after a diesel fuels HF injection event (40 CFR 144.52), as described in the section titled "How Do the Class II Well Operation, Mechanical Integrity, Monitoring, and Reporting Requirements Apply to HF Wells Using Diesel Fuels?"

[21]API recommends that casing used in oil and gas wells that will be hydraulically fractured meet API standards, including *API Specification 5CT* (API, 2005).

How Do the Class II Well Construction Requirements Apply to Already Constructed Wells Using Diesel Fuels HF?

Existing Requirements: Wells constructed prior to issuance of this guidance ("already constructed wells") may have been constructed and operated under requirements other than the federal UIC Class II requirements. In such cases, additional considerations should be taken into account when permitting these wells for HF using diesel fuels.

EPA UIC permit writers, under 40 CFR 146.22(d), may authorize an already constructed well for Class II injection activities if the owner or operator can demonstrate that injection using diesel fuels for HF will not result in movement of fluids into a USDW so as to create a significant risk to the health of persons. The demonstration includes requiring the owner or operator to obtain downhole logs and internal and external MITs prior to any HF injection activities using diesel fuels to ensure that well construction will prevent fluid migration into USDWs.

Recommendation: ***EPA UIC permit writers should ensure the owner or operator applies relevant construction-related requirements to already constructed Class II HF wells using diesel fuels to protect USDWs during injection for HF using diesel fuels per 40 CFR 144.52(a)(9).*** EPA UIC permit writers should consider consulting with the oil and gas program that may have permitted the well (e.g., during past production operations) to learn about the well's compliance history or other relevant information in order to make permit determinations about the appropriateness of permitting the well for UIC Class II diesel fuels HF use.

Some already constructed oil and gas wells may not provide an adequate level of protection for USDWs when undergoing diesel fuels HF-related injection, due to either the age of the well or to less stringent well construction standards that were in place when the well was constructed. For example, an older existing well may not be cemented to the lowermost USDW or construction may not be adequate to withstand proposed injection pressures anticipated during diesel fuels HF. If a well does not provide adequate protection for USDWs, then the EPA UIC permit writer should require the owner or operator to perform actions to ensure that USDWs are not endangered. Actions to repair a well include, but are not limited to, replacing the injection well tubing or cementing across specific sections of the well that intersect potentially vulnerable formations to decrease the risk of fluid movement. If corrective measures are not sufficient to protect USDWs, EPA recommends that a permit not be issued, in accordance with requirements under 40 CFR 144.12.

How Do the Class II Well Operation, Mechanical Integrity, Monitoring, and Reporting Requirements Apply to HF Wells Using Diesel Fuels?

Well Operation

Existing Requirements: Injection well operating requirements for Class II wells are found at 40 CFR 146.23(a). They require that, at a minimum, injection pressure should be limited so that injection does not cause the propagation of new fractures in confining zone(s) adjacent to USDWs. The purpose of these requirements is to ensure that the integrity of confining zones protecting USDWs is maintained and that injection pressures do not cause the movement of

injection or formation fluids into USDWs. In addition, the existing operation requirements and recommendations below also promote the adoption of best practices in well pressure management, as recommended by the SEAB on August 18 and November 18, 2011, to avoid methane migration and leakage and to protect water quality.

Recommendations: ***EPA UIC permit writers should consult with the owner or operator about the design and anticipated results of a proposed fracturing operation.*** It is important to establish operating requirements that are appropriate to the proposed diesel fuels HF operation and that account for past HF activities in each geographic area or field. Historical production and HF activities may have created fracture networks that will interact with future HF using diesel fuels. Awareness of the existing fracture network location and anticipation of fracture interactions when designing new HF operations will decrease the risk of endangerment to USDWs. The consultation increases the ability for owners or operators to incorporate recommended approaches into the modeling often used to design and determine parameters of a proposed diesel fuels HF operation.

EPA UIC permit writers should consider construction design and geologic conditions when determining the maximum injection pressure for a UIC permit (per 40 CFR 144.52(a)(9)). EPA UIC permit writers should examine the fracture gradient of the injection zone to determine fracture pressure and to avoid damage to the confining zone, which acts as a barrier to protect USDWs. Calculations of maximum injection pressure should also consider the properties of the construction materials to withstand HF.

EPA UIC permit writers should ensure that wells used for diesel fuels HF incorporate appropriate controls (e.g., pressure limitations) so that integrity of the confining zone(s) protecting USDWs are maintained in order to comply with 40 CFR 146.23. This recommendation is of particular importance because many oil and gas extraction practices tend to reduce pressures in the formation, and typical oil and gas production regulations are designed for these circumstances. Typical injection activities, including diesel fuels HF, increase formation pressures; UIC regulations and associated permit conditions generally address risks associated with pressure increases, while typical oil and gas production requirements likely do not address these risks.

Mechanical Integrity Testing

Existing Requirements: Mechanical integrity testing is a specialized type of testing that ensures there is no significant leak in the casing, tubing or packer, and no significant fluid movement into a USDW through vertical channels adjacent to the well (40 CFR 146.8). Mechanical integrity requirements, found at 40 CFR 146.8, describe methods for demonstrating mechanical integrity of well components. Provisions in 40 CFR 146.23(b)(3) require that owners or operators of Class II wells conduct a mechanical integrity test (MIT) at least once every five years during the life of the well.

MITs ensure that the protective components of the well are intact prior to injection and over the life of the well. High pressures have the potential to damage the integrity of the well. Well integrity must be maintained at all times, including during times of HF using diesel fuels when the well is subjected to high injection/fracture pressures and during any subsequent high-pressure

refracturing events. MIT requirements and EPA's recommendations below promote the adoption of best practices in well pressure management, as recommended by the SEAB on August 18 and November 18, 2011, to avoid methane migration and leakage and protect water quality.

Recommendations: ***EPA UIC permit writers, consistent with his or her authorized discretion under 40 CFR 144.52(a)(9), should ensure owners or operators of Class II diesel fuels HF wells conduct internal and external MITs before the first stimulation and again after completing all stages of hydraulically fracturing a well in order to comply with 40 CFR 146.8.***

EPA UIC permit writers should include the following procedures (40 CFR 146.8(b)) to assess mechanical integrity and ensure USDW protection during the operational phase of a Class II HF well using diesel fuels, consistent with their authorized discretion under 40 CFR 144.52(a)(9):

- Pressure testing the well prior to perforating the well at pressures equal to or exceeding the maximum expected pressure during any HF event to ensure that the pressure does not compromise the integrity of the tubing and casing. Pressure testing at a pressure sufficient to determine if the casing integrity is adequate to meet design and construction objectives is consistent with recommendations in API Guidance Document HF1(API, 2009);

- Submitting a cement bond log accompanied by a knowledgeable log analyst's interpretation for each casing string, cementing records, cement bond analyses, and any other logs determined by the EPA UIC permit writer to be necessary for review and approval by the EPA UIC Program Director prior to perforating a Class II diesel fuels HF well. Cement bond logs can provide an assessment of the presence or absence of cement and how effectively cement is bonded to the pipe, but are not themselves an approved MIT; and

- Submitting a post-fracture tracer log in conjunction with a temperature log for review and approval by the EPA UIC Program Director after perforating a Class II diesel fuels HF well. The tracer log and temperature log indicate whether fractures have penetrated the confinement zone and whether the well's integrity will prevent significant fluid movement through vertical channels adjacent to the injection well bore. This recommendation is consistent with API Guidance Document HF1, which recommends the use of post-HF tracer or temperature logs (API, 2009).

Monitoring and Reporting

Existing Requirements: Collection and review of monitoring data allows EPA UIC permit writers to evaluate the direction and extent of the fracture network and to effectively confirm that USDWs have not been endangered as a result of poor well construction or improper operation of diesel fuels HF wells. Monitoring data may also help owners or operators to further refine computer models used to design future HF operations. Existing Class II regulations for monitoring are found at 40 CFR 146.23(b) and are applicable to HF where diesel fuels are used, as described in Table 1. These regulations outline requirements for monitoring and reporting of information before, during, and after a Class II well commences operation, to ensure the protection of USDWs. MIT requirements are also included in Table 1 and Table 2. Monitoring

and reporting requirements and recommendations fulfill a number of the August 18 and November 18, 2011 SEAB recommendations. They enable EPA to collect fracturing fluid composition data when diesel fuels are being used. The data generated would allow EPA to apply best practices in well development and construction and to establish baseline monitoring to protect water quality. The data also could enable EPA to provide assurance to the public that diesel fuels HF operations are being conducted safely.

Regulations at 40 CFR 144.52(a)(9) allow or provide for EPA UIC permit writers to require more frequent monitoring to prevent migration of fluids into USDWs. EPA UIC permit writers need only submit a minor permit modification under 40 CFR 144.41 to require more frequent monitoring and/or reporting, including during construction and once a Class II HF well using diesel fuels has commenced fracturing operations. Moreover, current regulations at 40 CFR 144.51(k)(6) require the owner or operator to report to the [EPA] UIC Program Director within 24 hours of any monitoring that indicates that a contaminant may endanger a USDW, or any malfunction that may cause migration of fluids into USDWs. The availability of comprehensive data and the EPA UIC permit writer's flexibility in the application of monitoring requirements helps support the establishment of effective field monitoring and enforcement to inform ongoing assessment of cumulative community and land use impacts as recommended by the SEAB on August 18 and November 18, 2011.

Table 1. Monitoring and Reporting Requirements for UIC Class II Wells.

	CFR Citation	Required Activities	Required Timing	Purpose
Fluids Monitoring	146.22(f)	Conduct logging and testing and conduct an assessment of injection zones, confining zones, and adjacent formations; prepare a report synthesizing logging and testing results	During drilling and construction	Provides data and information on the subsurface, including the location of injection zones, confining zones, and adjacent formations; informs permitting decisions to prevent migration of injected fluids into USDWs and ensure USDW protection
	146.23(b)(1)	Monitor the nature of injected fluids	At a frequency sufficient to yield data representative of the fluid characteristics	Provides an understanding of the potential risks of fluid migration
	146.23(b)(2)(ii)	Monitor injection pressure, flow rate, and cumulative volume	At least monthly	Ensures protective injection well operational parameters are met

	CFR Citation	Required Activities	Required Timing	Purpose
MIT	146.23(b)(3)	Conduct mechanical integrity testing	At least once every five years during the life of a project	Determines well component integrity and/or if corrective action is needed to prevent vertical migration through the well bore
Reporting & Record-Keeping	144.51(k)(6)	Report any emergency or noncompliance event which may endanger human health or the environment	Verbally, within 24 hours/In writing, within five days of an emergency or noncompliance event	Provides for timely initiation of remedial action
	144.51(m)	Notify the [EPA] UIC Program Director that construction is complete and await approval before commencing injection	After well construction completion	Provides the EPA UIC Program Director information to ensure well construction is protective of USDWs prior to operation
	146.23(b)	Report information collected under 146.23(b)(1) before, during, and after a Class II well (including Class II HF wells using diesel fuels) commences operation	Varies, depending on type and characteristics of the activity being monitored	Ensures maintenance of well integrity so that injected fluids do not migrate into USDWs; informs remedial action, if needed

	CFR Citation	Required Activities	Required Timing	Purpose
	146.23(c)(1) & (2)	Submit a summary report of all monitoring[22]	Annually	Allows the EPA UIC Program Director to review activities and ensure the permit conditions are met
Record Retention	144.51(j)(2)(i) & 144.51(j)(2)(ii)	Retain all calibration and maintenance records; original strip chart recordings for continuous monitoring; copies of all reports required by the permit and data used to complete the permit application; and, monitoring records on the nature and composition of all injected fluids	Retain for three years from the date of the sample, procedure, measurement, report,[23] or application	Confirms safe and protective injection; informs future activities in the AoR and any necessary remedial action
	146.23(b)(4)	Maintain results of all monitoring	Until the next permit review	Confirms USDW protection during injection; informs future activities in the AoR and any necessary remedial action

Recommendations: ***EPA UIC permit writers should modify monitoring and reporting protocols, consistent with their authorized discretion under 40 CFR 144.52(a)(9), so that the permit writer has adequate information to determine that each planned HF operation using diesel fuels will not endanger USDWs.*** EPA UIC permit writers should modify the approaches from the typical Class II monitoring and reporting, while still meeting the UIC regulations, to address the intermittent, or infrequent, nature of HF using diesel fuels, as described in Table 2. EPA UIC permit writers could accommodate alternative requirements during periods where injection is not occurring. Less stringent requirements that remain protective of USDWs may include less frequent monitoring and reporting or monitoring fewer parameters.

EPA UIC permit writers should ensure the owner or operator monitors pump rate, pressure, volume and viscosity of the fracturing fluid to evaluate the results of the diesel fuels HF operation—such as fracture vertical length, lateral extent. Based on recommendations from sources including API, these parameters are critical to confirming protection of USDWs. Data that can be collected during the treatment operation to monitor and control operations in real-time include continuously monitored surface injection pressure, injection rate and volume, slurry rate, and percentage proppant. An owner or operator may also choose to use microseismic and

[22] Owners or operators of ER wells may report on a field or project basis rather than an individual well basis.
[23] For EPA administered programs, the owner or operator shall retain records beyond three years, unless records are delivered to the RA or the RA gives written approval to discard them.

tiltmeter surveys as suggested by *API Guidance Document HF1*(API, 2009) to achieve real-time mapping of a HF treatment in progress.

Table 2. Recommended Monitoring and Reporting for UIC Class II HF using Diesel Fuels.

Activity	Recommendation	Rationale
Pressure testing	Pressure testing at pressures equal or above the expected diesel fuels HF injection pressure, both prior to and after each diesel fuels HF activity	Ensures well maintains mechanical integrity during and after a diesel fuels HF activity
Cement bond logs	Submittal of radial cement bond logs for each casing string with interpretation, cementing records, cement bond analyses, and any other logs or records	Provides proof that cement has been properly and sufficiently emplaced to prevent migration of fluids into USDWs
Pressure recording devices	Equip wellhead with pressure recording devices on all available annuli and injection strings with a pressure rating equal to or exceeding the maximum pressure expected during any diesel fuels HF operation	Will detect any loss of integrity of the outer cement sheath around the long-string wellbore during the fracturing process

How Do the Class II Financial Responsibility Requirements Apply to Wells Using Diesel Fuels for HF?

Existing Requirements: Like other classes of injection wells, a demonstration of financial responsibility (or available resources) is required before any Class II well operation, including diesel fuels HF operations, can be performed. Regulations for Class II wells require the demonstration of financial responsibility to cover the costs of closing, plugging, and abandoning an underground injection well (40 CFR 144.52(a)(7)). The demonstration and maintenance of financial responsibility is a permit condition that is required until: (a) the well is closed in accordance with an approved plugging and abandonment plan; (b) the well has been converted to production (i.e., no longer injecting for the purposes of the UIC Program); or (c) the transferor of a permit has received notice from the [EPA] UIC Program Director that the new permittee has demonstrated financial responsibility for the well (40 CFR 144.52(a)(7)). Submission of surety bonds, financial statements, or acceptable materials to show evidence of financial responsibility is required.

EPA UIC permit writers may periodically require revisions to the financial responsibility demonstration. This includes an update to the cost estimate of the resources needed to plug and abandon the well to reflect inflation of such costs.

Class II diesel fuels HF operations may at some point cease injection and begin oil and gas production. Financial responsibility must be maintained under the UIC permit until the well has been closed, plugged, and abandoned, or at least for the duration of the permit in cases where wells are converted out of the UIC Program and into oil and gas production (see “How Should

EPA UIC Permit Writers Establish a Permit Duration and Apply UIC Well Closure Requirements After Fracturing at a Well Ceases?" for applicable information on permit duration and well conversion).

Recommendations: ***EPA UIC permit writers should ensure that owners or operators refer to previously published guidance on EPA-administered UIC Programs for additional context on the recommendations related to financial responsibility with respect to diesel fuels HF described in this guidance (USEPA, 1990).*** The goal of EPA guidance on financial responsibility for Class II operations is to ensure that adequate financial resources are available to properly plug and abandon injection wells, as necessary, to protect USDWs by presenting a flexible set of criteria that may be applied with appropriate judgment.

EPA UIC permit writers should thoroughly examine proposals that use a financial test or corporate guarantee for self insurance. Compared to third-party instruments (e.g., trust fund, surety bond, letter of credit), self insurance may pose a higher risk of instrument failure (USEPA, 2005; U.S. Government Accountability Office, 2005). If an owner or operator selects self insurance, EPA UIC permit writers should evaluate whether the risk of instrument failure is acceptable for ensuring that USDWs will not be endangered.

EPA UIC permit writers should include coverage for the total number of wells in an area permit for Class II HF wells using diesel fuels—i.e., the sum of costs for each well covered by an area permit—when determining the extent of financial responsibility required. An acceptable financial responsibility demonstration will indicate that the face value of the financial instrument (i.e., third party financial instruments or self-insurance demonstration) meets or exceeds the plugging costs specified in the Plugging and Abandonment Plan (EPA Form 7520-14) for all wells.

What Public Notification Requirements or Special Environmental Justice (EJ) Considerations are Recommended for Authorization of Wells Using Diesel Fuels for HF?

Existing Requirements: Public notification requirements for all UIC well classes are addressed in 40 CFR Part 124. Under these requirements, the [EPA] UIC Program Director must give notice to the public of all permit actions, including when a permit has been tentatively denied, a draft permit has been prepared, a hearing has been scheduled, or an appeal has been granted. The public must be given 30 days to comment on a draft permit and 30 days notice of a planned hearing (40 CFR 124.10). During the 30-day comment period for a draft permit, any interested person may request a hearing (40 CFR 124.11). The public notification requirements were established to enable interested stakeholders to give input into the UIC permitting process. EPA UIC permit writers must follow these and all requirements mentioned above and at 40 CFR Part 124 for public notification when permitting a Class II HF well using diesel fuels. The existing public notification requirements for UIC wells and EPA's recommendations below improve public information available about shale gas operations as advocated by the SEAB on August 18 and November 18, 2011.

Recommendations: ***The owner or operator and the EPA UIC permit writer should begin planning for public notification as soon as a new injection well is proposed to give the maximum amount of time for effective communication while not affecting the project schedule.*** Public participation will help permitting authorities understand public concerns about these projects. Public participation activities will also give the public an opportunity to gain a clearer understanding of the benefits and risks of the planned diesel fuels HF activity. By beginning outreach early, both the EPA UIC permit writer and the owner or operator have more flexibility to consider and address stakeholder concerns. Earlier stakeholder outreach can help mitigate controversial issues and avoid litigation and project delays. One way to achieve earlier public notification is to build on requirements at 40 CFR 144.31(e)(9), which specify that permit applicants to EPA-administered programs should identify and submit with the permit application the names and addresses of all land owners within one-quarter mile of the facility boundary, unless waived by the EPA UIC Program Director. EPA UIC permit writers could request owners or operators to send in land owner contact information required in the permit application and also send out details regarding the proposed diesel fuels HF project in advance of submitting the permit application.

EPA UIC permit writers and owners or operators should make a special effort to consider environmental justice in the permitting process for diesel fuels HF. The following sub-section, "Incorporating Environmental Justice Considerations," provides a description of how this could be done.

Incorporating Environmental Justice Considerations

Presidential Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 FR 7269, Feb. 16, 1994), states that "federal agencies shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or

environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories…"

EPA's comprehensive Plan EJ 2014 is the Agency's roadmap to integrating environmental justice into its programs and policies. Plan EJ 2014: Considering Environmental Justice in Permitting, is intended to enable overburdened communities to have full and meaningful access to the permitting process and to develop permits that address environmental justice issues to the greatest extent practicable. This is the implementation plan for developing a suite of cohesive tools and a larger public database of many other tools to serve as a resource for EPA and all interested stakeholders to utilize during the permitting process. Potential tools in development include guidance, best practices, and fact sheets on permit processes, public involvement and communication, permit conditions, and interagency protocols. When made available, EPA UIC permit writers should consult these resources and work with owners and operators to reduce or mitigate any potential EJ impacts of a proposed DFHF activity. Information is available at: http://www.epa.gov/compliance/ej/plan-ej/index.html. Extra efforts in this regard are particularly important in light of the widespread interest in impacts of HF on communities.

Does this Guidance Apply to States, Tribes, and Territories with Primacy?

No, this guidance is intended for EPA UIC direct implementation permit writers. However, EPA encourages states, tribes, and territories ("states") with UIC primacy to use the information provided herein as appropriate when implementing the state's existing regulatory framework.

Existing Requirements: SDWA Section 1421(b)(1)(A) requires primary enforcement (primacy) authorities to either permit underground injection or prohibit the activity. The guidance lays out requirements and recommendations that state primacy programs may draw from; however, the specific way a state primacy program chooses to address permitting of diesel fuels HF may vary for a number of reasons. For example, state UIC primacy programs may have received their authorities under different sections of the SDWA (i.e., Sections 1422 or 1425), which offers different parameters for their regulatory framework. Also, state laws for UIC are often integrated with oil and gas laws, requiring close coordination across programs.

Differences exist between the authorities that SDWA Sections 1422 and 1425 give to primacy programs and the subsequent implementation of the program.

- Under SDWA Section 1422, states must demonstrate that their proposed UIC Program meets the statutory requirements under SDWA Section 1421 and that their program contains requirements that are at least as stringent as the minimum federal requirements provided for in the UIC regulations.

- States that seek primacy under SDWA Section 1425 still must meet the statutory requirements under SDWA Section 1421 and have the option to demonstrate that their Class II Program is an effective program that prevents underground injection which may endanger drinking water sources. The optional demonstration provides more flexibility for the state program to vary from the federal UIC Program regulations.

Primacy application, review, and approval under both Sections 1422 and 1425 of the SDWA require that a state submit a complete UIC Program application. If the application meets the SDWA requirements and its implementing regulations, the state receives approval to implement and enforce the UIC Program through a rulemaking signed by the EPA Administrator and published in the *Federal Register*. Approved UIC primacy programs are codified at 40 CFR 147. In primacy states, the state implements the UIC Program while EPA retains an oversight role and may commence enforcement actions under specific conditions if an owner or operator violates a UIC requirement (SDWA Section 1423) or endangers a USDW (SDWA Section 1431).

Because decisions regarding how a state, and including which state agency, implements the UIC Program rest with the state, UIC Program implementation and agency authorities are unique to each state. Thirty-nine states, three territories, and two tribes have received primacy for the Class II Program. Twenty-three of the 39 primacy states and the two tribes implement Class II Programs under SDWA Section 1425. Sixteen states and three territories have received primacy under SDWA Section 1422. EPA directly implements the UIC Program in the remaining 12 states and two territories, plus all other remaining Indian country.

States and other federal agencies have or may have rules for other, non-diesel fuels injection aspects of HF and oil and gas development, including surface management, which are beyond the scope of this document. States and EPA should coordinate with federal agencies, such as BLM and the U.S. Forest Service, to ensure compliance with all applicable requirements.

Recommendations: On August 18, 2011, the SEAB's Shale Gas Production Subcommittee recommended eliminating use of diesel fuels as an additive to HF fluids. A primacy state could choose to eliminate HF using diesel fuels by prohibiting its use under state law. If states choose not to prohibit diesel fuels HF through legislation, EPA encourages states to find additional ways of integrating UIC and oil and gas program requirements where appropriate to increase protections for USDWs. Where state oil and gas production programs have production well requirements that are consistent with UIC Class II requirements for HF wells using diesel fuels, they may defer to these requirements to implement the program, although a UIC permit will still be necessary. In such cases, owners or operators may already be in compliance with certain UIC Class II requirements.

States may use varying approaches to permitting. These approaches include, but are not limited to, the following:

- *Using Dual Authority Permits*: Creating one, dual-authority permit with combined permit conditions applicable to both injection and production well operations. Submitting this information in one permit application may enhance efficiency of permit issuance, especially where UIC Class II requirements and oil and gas production requirements are similar and the owner or operator has gathered the appropriate information to satisfy both types of requirements;

- *Allowing Centralized Report Submittal*: Allowing submittal of streamlined completion, monitoring and testing, and plugging and abandonment reports to a central entity which

meets the reporting requirements of both programs to increase reporting efficiency and enable comprehensive evaluation of information;

- *Conducting Joint Inspections*: Coordinating inspections of UIC Class II diesel fuels HF wells and production wells to enable efficient use of skilled personnel; and

- *Allowing Joint Financial Responsibility Mechanisms*: Using financial responsibility mechanisms for UIC permitting that are similar to or the same as those used for production wells to facilitate efficient permitting.

In states where different entities manage the UIC and the oil and gas programs, establishing an MOU may be appropriate to delineate each agency's respective authorities over the diesel fuels HF process and to facilitate the shared collection and use of common information and reporting elements. Such memoranda are currently employed in the UIC Program to facilitate permitting and program oversight between EPA and states, and between state agencies. Examples of such agreements include those between state agencies in Texas,[24] and those between the Colorado Department of Public Health and Environment, the Colorado Department of Natural Resources, and the Colorado Oil and Gas Conservation Commission.[25]

To help identify potential UIC permit applicants, permitting authorities are encouraged to alert owners or operators of production wells of their obligation to obtain a UIC injection well permit prior to engaging in HF with diesel fuels.

Although implementing these cooperative methods is not required for permitting diesel fuels HF under the UIC Class II program, states may choose to adopt one or more of these approaches for their convenience. Many states may have existing Class II authority where they could permit diesel fuels HF without changes to state laws or regulations. However, EPA recognizes that some states' existing statutory and regulatory authorities may limit their ability to implement the suggested approaches. In such cases, a state may consider modifying existing regulations, statutes, or processes to accommodate these approaches if they feel it is necessary, or they may use other approaches that satisfy the requirements of the SDWA. In addition, several of the suggested approaches may constitute a "program revision," such as establishing a mechanism for an entity other than the EPA-authorized UIC Program to permit UIC diesel fuels HF wells. Prior approval from EPA is required in the event that a state wishes to revise an approved UIC Class II primacy program.

[24] See signed memorandum at http://info.sos.state.tx.us/pls/pub/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=16&pt=1&ch=3&rl=30.

[25] See signed memorandum at http://www.cdphe.state.co.us/op/wqcc/Reports/SB181/moaogcc.pdf.

Conclusion

This draft guidance describes how Class II regulations may be tailored to address the risks of diesel fuels injection during HF, consistent with the provisions at 40 CFR Parts 124 and 144 through 147. Primacy programs have greater flexibility in addressing the SDWA requirement to permit diesel fuels HF, but are nevertheless encouraged to review and consider the information and recommendations in the guidance.

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Appendix A

Pathways of Contamination and UIC Requirements Designed to Mitigate Risks to USDWs

Pathways of Contamination and UIC Requirements Designed to Mitigate Risks to USDWs

The fundamental purpose of the UIC Program is to prevent the contamination of current and potential underground sources of drinking water (USDWs) by keeping injected fluids within the injection well and the intended injection zone. There are six major pathways by which injected fluids can migrate into USDWs, as follows:

1. Migration of fluids through a faulty injection well casing;

2. Migration of fluids through the annulus located between the casing and well bore;

3. Migration of fluids from an injection zone through the confining strata;

4. Vertical migration of fluids through improperly abandoned and improperly completed wells;

5. Lateral migration of fluids from within an injection zone into a protected portion of that stratum; and

6. Direct injection of fluids into or above an USDW.

More detail about each pathway and the major technical UIC requirements developed to mitigate the associated risks to USDWs are provided below.

Pathway 1 – Migration of Fluids Through a Faulty Injection Well Casing

Injection well casing serves multiple functions. It supports the well bore to prevent collapse of the hole and resultant loss of the well; serves as the conduit for injected fluids from the land surface to the intended injection zone; and supports other components of the well. If a well casing is defective or compromised, injected fluids may leak through it, potentially resulting in USDW endangerment.[1,2] To prevent migration of fluids through the casing, well casing should be sufficient to prevent the movement of fluids into any USDWs.

UIC regulations require injection well owners or operators to comply with specific operational requirements designed to minimize migration of fluids through the casing. Foremost among these are the requirements to demonstrate and maintain mechanical integrity (40 CFR 146.8). An

[1] USEPA. January 1977. The Report to Congress, Waste Disposal Practices and Their Effects on Ground Water, Sections XI, XIII ("Report to Congress").
[2] USEPA. December 1977. An Introduction to the Technology of Subsurface Wastewater Injection. Chapter 7 ("Subsurface Wastewater Injection").

MIT is used to verify mechanical integrity of the well and confirm the absence of significant leaks.[3,4]

Well integrity can be demonstrated by testing for the absence of significant leaks in the casing, tubing, or packer and the absence of significant fluid movement into USDWs. The regulations, at 40 CFR 146.8 afford owners or operators and Directors options of tests that may be used to detect leaks and fluid movement.

A second protective feature of the UIC Program regulations is that injection wells are constructed with tubing and packer, fluid seal, or an approved alternative. Tubing and packer well construction is employed to isolate the casing of the well from injected fluids. Preventing contact between casing and injected fluids reduces the potential for movement of fluids through leaks in the casing and into USDWs.

Pathway 2 – Migration of Fluids Through the Annulus Located Between the Casing and the Well Bore

A second potential pathway by which contaminants can reach USDWs is the upward migration of fluids through the annulus.[5] Under usual injection conditions, injected fluids leave the injection well and enter a stratum that allows the entry of the fluids to varying degrees.[6] Because fluids tend to take the path of least resistance, unless properly contained, they may travel through the wellbore annulus. If sufficient injection pressure exists, the injected fluids could flow into an overlying or underlying USDW.

Measures for the prevention of fluid migration through the annulus (Pathway 2) are the same as those discussed previously for Pathway 1 mitigation. Injection well owners or operators must demonstrate to the satisfaction of the UIC Program Director that there is no significant fluid movement into or between USDWs through the annulus. MITs must be conducted to confirm well integrity and the absence of fluid movement (40 CFR 146.8).

Pathway 3 – Migration of Fluids from an Injection Zone Through the Confining Strata

The third migration pathway the UIC requirements are designed to prevent is fluid migration from the injection zone, through the confining zone, into overlying or underlying USDWs. Upon entry into an injection zone, fluids injected under pressure typically travel away from the well laterally into the receiving formation. In limited situations, if the confining stratum which separates the injection zone from an overlying or underlying USDW is either fractured or permeable, the fluids may migrate out of the receiving formation and into USDWs.

[3] See requirements at 40 CFR 146.8.
[4] Geraghty and Miller, Inc. April 30, 1980. Mechanical Integrity Testing of Injection Wells.
[5] The space between the drilled hole/borehole and the injection well casing.
[6] Resistance results from friction created by extremely small openings (pores) in the materials which comprise the injection zone.

The UIC regulations include site characterization, site selection, operation, and permitting requirements to prevent fluid migration into USDWs through the confining zone. The regulations require owners or operators to collect and submit comprehensive, site- and project-specific data including information on the geologic characteristics of the injection zone and confining zone(s) to the UIC Program Director for review prior to permit issuance(40 CFR 146.14(a)(l), 146.24(a)(l), 146.34(a)(l)). Historical data may assist EPA UIC permit writers in evaluating an injection well site. An injection well permit should only be issued upon the EPA UIC permit writer's finding that the injection zone is appropriate to receive and retain the injectate and that the confining zone(s) are appropriately characterized and sufficient to contain fluids in the injection zone.

The regulations require that well injection pressure be controlled to prevent opening fractures in the confining strata or otherwise causing the rise of fluids out of the injection zone and into USDWs (40 CFR 146.6). These requirements afford the UIC Program Director discretion to establish injection pressures appropriate for the injection operation.

Pathway 4 – Vertical Migration of Fluids Through Improperly Abandoned and Improperly Completed Wells

UIC site characterization and permitting requirements are designed to mitigate risks associated with fluid migration through improperly abandoned and improperly completed wells into USDWs (Pathway 4). Such migration could occur if fluids move laterally within an injection zone, encounter improperly abandoned or completed wells, and flow upward within the well into an overlying USDW or reach the surface. Due to the large number of wells drilled in the past and limitations on historical records, mitigation of fluid movement through this pathway is critical.

To prevent fluid migration through improperly abandoned or improperly plugged wells into USDWs, the regulations require owners or operators to delineate an AoR for each injection well or operation and to identify and locate all wells within the AoR and correct any problems related to improperly abandoned or improperly completed wells before commencing injection. Under this approach, injection well owners or operators must demonstrate that the proposed injection operation will not result in fluid migration into USDWs or USDW endangerment.

Pathway 5 – Lateral Migration of Fluids from Within an Injection Zone into a Protected Portion of that Stratum

In most geologic settings and injection scenarios, the injection zone of a particular injection operation will be physically segregated from USDWs by an impermeable confining zone or a series of formations. However, there may be limited circumstances where injection well owners or operators may inject into a non-USDW (a formation not afforded SDWA protection) which is laterally connected to, or proximal to, a USDW. In such situations there may be no impermeable layer or other barrier present to prevent fluid migration into USDWs (Pathway 5).

Injection into non-USDW formations that are laterally connected to USDWs may be permitted depending upon the geologic setting and operational conditions. In such situations, the owner or operator and the EPA UIC permit writer must carefully evaluate the site characterization, well

construction, and proposed well operation data when establishing permit conditions to ensure that the injectate remains in the injection zone and does not migrate laterally into USDWs. The UIC regulations afford the UIC Program Director discretion to establish appropriate permit conditions on a project-specific basis to ensure USDW protection.

Pathway 6 – Direct Injection of Fluids into or above an Underground Source of Drinking Water

The final pathway mitigated by specific UIC injection well requirements is that of direct injection of fluids into or above a USDW. Such injection presents an immediate risk to public health because it can directly degrade groundwater, especially if the injected fluids do not benefit from any natural attenuation from contact with soil, as they might during movement through an aquifer or separating stratum. To address this concern, the UIC Class II regulations prohibit injection of contaminants directly into USDWs.

Appendix B

Methods for Calculating the Area of Review

Methods for Calculating the Area of Review

Method Selection

The UIC regulations at 40 CFR 146.6 provide for two approaches to delineating the area of review (AoR): a mathematical approach for calculating a zone of endangering influence (ZEI) and a fixed-radius approach. When choosing which approach to require for diesel fuels HF wells, EPA UIC permit writers should consider that the purpose of delineating the AoR is to identify the area throughout which the owner or operator must search for conduits, such as abandoned wells, that could enable fluids containing diesel fuels to migrate from the injection zone into a USDW.

Calculating the Zone of Endangering Influence (ZEI)

The ZEI is the lateral area in which the pressures in the injection zone may cause injection or formation fluid to migrate into a USDW. In the case of area permits, the ZEI is the project area plus a circumscribing area in which the pressures in the injection zone may cause injection or formation fluid to migrate into a USDW.

The UIC regulations at 40 CFR 146.6(a)(2) provide a formula, known as the modified Theis equation, as an example for calculating the ZEI for a vertical well, pumping over time, in an injection zone. A HF operation creates, within a very-low permeability geologic stratum, a localized, high-density network of interconnected fractures that is very capable of transporting the HF fluids generally consisting of water with a diesel-fuel component. This system may be considered as a porous and confined injection zone, and can serve to illustrate why use of the modified Theis equation for calculating ZEIs for long lateral well completions used in HF is problematic. Any application of the modified Theis equation requires that the well-test scenario meet several radial-flow assumptions. Specific vertical-well scenarios may not fully meet all those assumptions, but horizontal, or directionally completed, HF well scenarios significantly violate the following three Theis assumptions:

1. *The injection well penetrates the entire thickness of the injection zone:* While the vertical measurement of the directional completion in a diesel fuels HF application is measured in tens of feet, the vertical thickness of the hydraulically fractured zone is generally several hundreds of feet. Therefore, the directional completion does not approximate a well that fully penetrates the injection zone.

2. *The injection zone is of infinite areal extent*: In a diesel fuels HF application, the injection zone is of limited areal extent within a very low permeability geologic stratum.

3. *The trace of the well onto the land surface is infinitesimal:* In a diesel fuels HF application, the trace of a horizontal, or directionally drilled well onto the land surface is not small; rather, it is a line of significant length.

Because the modified Theis equation leads to significant errors if used to calculate the ZEI for a directional completion, EPA does not support its use in this particular circumstance.

The EPA UIC permit writer may instead consider numerical models, supported by sufficient field data, to be appropriate to apply to the specific geologic setting. The use of numerical models requires significant data collection, and therefore, costs may increase.

Using the Fixed One-Quarter (¼) Mile Radius

The second approach for conducting the AoR delineation provided in 40 CFR 146.6 is to use a fixed radius methodology. The owner or operator may use a fixed radius of at least one-quarter (¼) mile around the well bore, as the AoR instead of calculating the ZEI, with the approval of the UIC Program Director. The fixed radius is most readily applied to vertical wells.

However, for non-vertical wells, it is necessary to account for the directional portion of the well in order to adequately protect USDWs. For these settings, EPA has developed the four options below to adapt the fixed one-quarter (¼) mile radius. The UIC Program Director, as authorized under 40 CFR 146.6, may require that the AoR be bounded by any of the following:

1. The trace on the land surface of the circumference of a sphere drawn around the directional completion of the well, where the sphere is centered at the mid-point of the directional completion, fully contains all hydraulically induced fractures and has a radius of no less than ¼ mile. (Note: fractures generally do not extend from the endpoints of a directional completion.) (Figure 1).

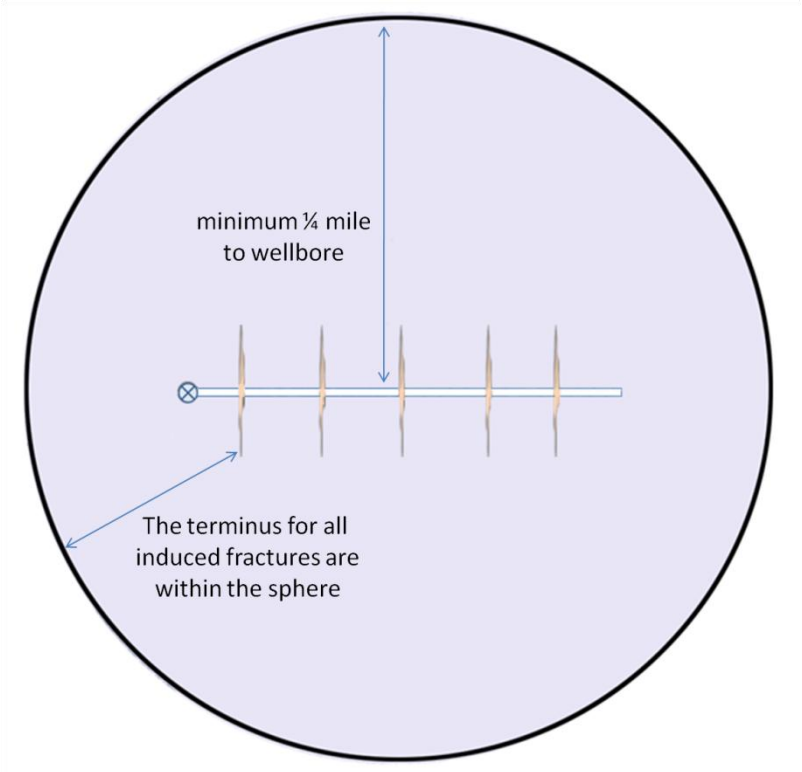

Figure 1: AoR for the trace on the land surface of the circumference of a sphere drawn around the directional completion of the well, where the sphere is centered at the mid-point of the directional completion, fully contains all hydraulically induced fractures and has a radius of no less than ¼ mile. (Note: Features are not drawn to scale.)

2. The trace on the land surface of the circumference of a sphere drawn around the directional completion of the well, where the sphere is centered at the mid-point of the directional completion, has a radius such that all fractures are completely contained and the termination points of the fractures are no closer to the sphere's circumference than one-quarter (¼) mile (Figure 2).

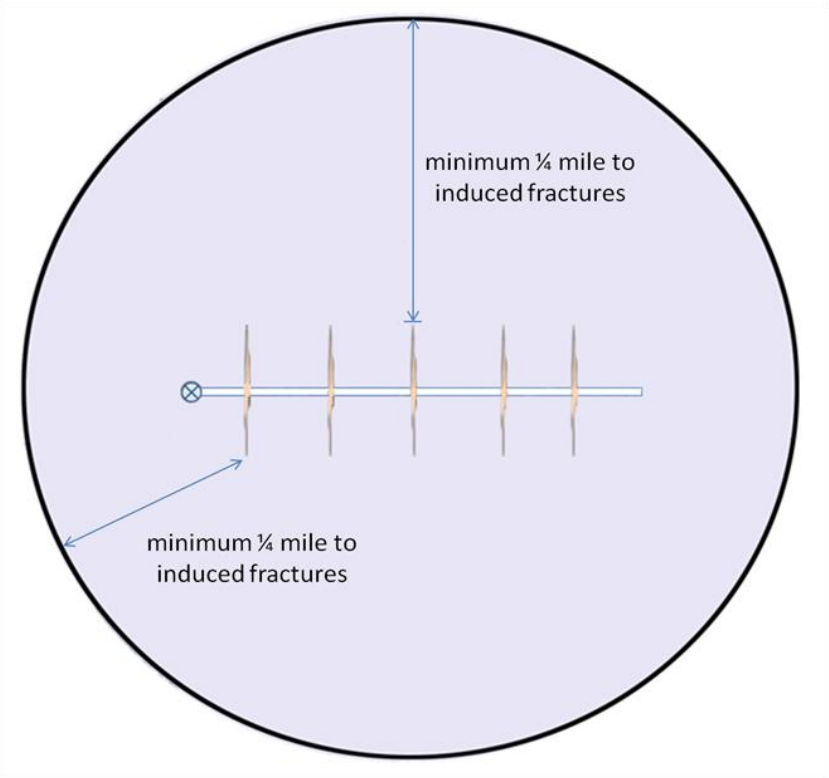

Figure 2: AoR for the trace on the land surface of the circumference of a sphere drawn around the directional completion of the well and centered at the mid-point of the directional completion. The sphere wholly contains all fractures, the termination points of which are no closer to the circumference than one-quarter (¼) mile. (Note: Features are not drawn to scale.)

3. The trace on the land surface of the boundary of a cigar-shaped setback from the directional completion, where the cigar shape around the directional completion fully contains all hydraulically induced fractures and has a radius of no less than one-quarter (¼) mile measured from the directional completion. (Note: Increasing the vertical angle of the directional completion reduces the length of the AoR's trace on the land surface.[1]) (Figure 3)

[1] As the angle of the directional completion approaches vertical, the trace on the land surface approaches a fixed radius around a vertical well.

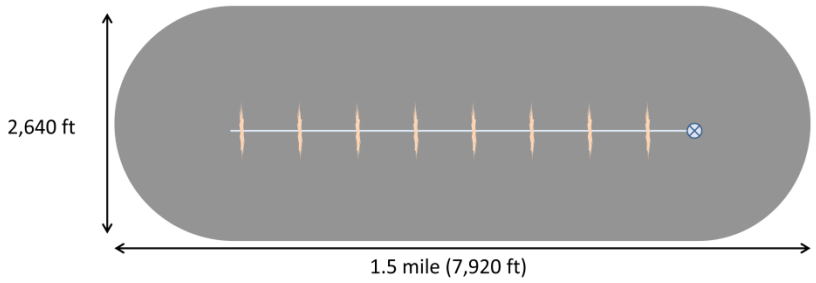

Figure 3: AoR for the trace on the land surface of the boundary of a cigar-shaped setback from the directional completion, where the cigar shape around the directional completion fully contains all hydraulically induced fractures and has a radius of no less than one-quarter (¼) mile measured from the directional completion. The total width of the cigar shape is 2,640 feet. (Note: Features are not drawn to scale.)

4. The trace on the land surface of the boundary of a cigar-shaped setback from the directional completion, where the setback is no less than one-quarter (¼) mile from the estimated end of the fractures. (Note: Increasing the vertical angle of the directional completion reduces the length of the AoR's trace on the land surface.[2])

   Figure 4, below, provides an example in which the AoR is defined by the trace on the land surface of a cigar shape drawn one-quarter (¼) mile beyond the endpoints of hydraulically induced fractures that extend 200 ft beyond the directional completion, for a total setback distance of 1,520 ft from the completion (fractures do not extend from the ends of the directional completion.) The completion is horizontal and one mile long. Note that the lateral boundaries of the AoR are curves that are, at their closest point, ¼ mile from the horizontal completion.

[2] As the angle of the directional completion approaches vertical, the trace on the land surface approaches a fixed radius around a vertical well.

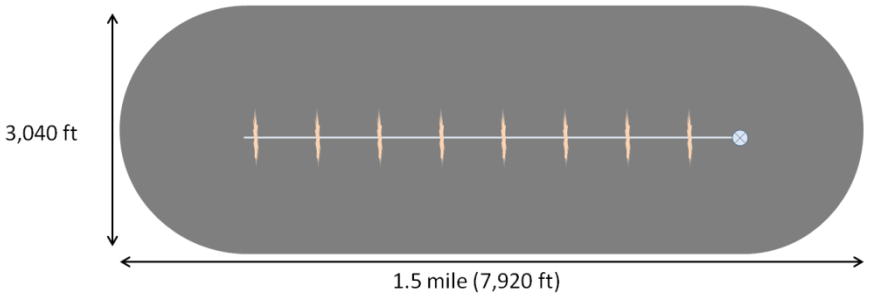

Figure 4. AoR for a cigar-shaped setback drawn ¼-mile beyond the endpoints of 200-feet long induced fractures along the length of a horizontally completed well. The total width of the cigar shape is 3,040 feet. (Fractures do not extend from the endpoints of the directional completion.) (Note: Features are not drawn to scale.)

Multiple horizontal wells are installed at many HF sites. The arrangement of these wells depends on the nature of the hydraulic properties of the zone targeted to undergo HF. Figure 3 presents an AoR that is a composite of the AoRs for three parallel horizontal wells.

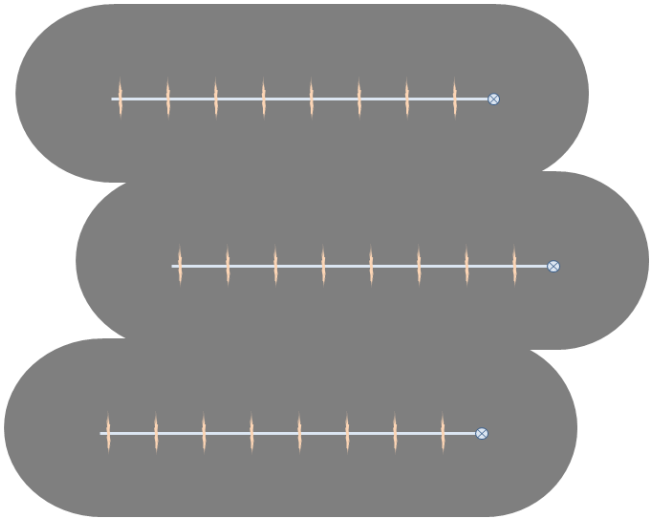

Figure 5. AoR that is a composite of the AoRs for three separate horizontal wells. (Note: Features are not drawn to scale.)

Area Permits. For an area permit, the AoR would be defined by the furthest extent of all well completions—lateral and vertical—plus a circumscribing area, the width of which is either:

1. At least one-quarter (¼) mile and no less than the estimated hydraulically induced fracture length, or

2. A distance calculated according to the criteria set forth in 40 CFR 146.6, but no less than needed to incorporate the farthest extent of fractures emanating from any well covered under the area permit.